The Carbon Baseline of Merthyr Valley Homes:

1 - Operational Expenditure

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1 Background and Introduction

This research note reports on the carbon footprint of Merthyr Valley Homes (MVH), a mutual housing association based in the Gellideg area of the town. We estimate the greenhouse gas emissions arising from the *operational expenditure* of the organisation during the period April 2021 to March 2022 (totalling around £21m).

This report is part of a larger project supported by Cardiff University and the ESRC Impact Acceleration Account entitled *Low Carbon Community, Low Carbon Economy: Building Re-localised, Sustainable and Prosperous Communities*. This project aims to help communities (including 'institutional communities' like MVH) understand and improve their socio-economic and environmental baselines, impacts and opportunities when facing our challenging future[1].

The next report in this series, in early 2023, will comprise a baseline estimate of the greenhouse gas emissions arising from the energy footprint of the MVH owned and operated housing and building stock - primarily some 4,000 properties rented to tenants. Our previous reports have estimated the economic Impact of MVH[2] and the carbon footprint of Treherbert, In the Rhondda Valleys[3].

This report estimates how MVH' £21m of 'direct' operational expenditure results in the emissions of greenhouse gases, comprising for example fuel directly burned In MVH offices and owned vehicles (Scope 1), from electricity use at these buildings, (Scope 2), and from the 'local and global' supply chain (Scope 3). This holistic analysis also estimates GHGs arising from the mutual's employees' household spending consequent on their wage income[4]. A future report will cover the GHG that arise from MVH homes.

The next section of this report details our carbon footprinting methodology and introduces the Input-Output Tables that form the heart of the analysis. We then report the results of our baseline estimation, detailing direct fuel burn and electricity purchases, supply-chain GHGs (and those related to housing maintenance & repair), and wage related GHGs separately. A final section concludes.

1 More information on this project is available from the current author
2 tbc
3 https://orca.cardiff.ac.uk/id/eprint/150091/
4 Although not, given the COVID-19 pandemic, their commuting.

2 Methodology & Data

2.1 The Environmentally Extended Input Output Tables for Wales

The Input-Output Tables for Wales have long been used to estimate the economic impact of sectors, events and organisations across Wales. Input-Output (IO) is a methodology that allows the estimation of the 'holistic' economic impacts of economic activity, directly (e.g., onsite at a business), along with the indirect or 'multiplier' impacts, along supply chains and as employees spend their earned incomes[5].

In 2021, the Tables were updated to base-year 2019 (thus reflecting Wales in the last, 'normal' pre-pandemic year), and extended to include estimates of the greenhouse gas emissions associated with Welsh economic activity; arising territorially in Wales, in the rest of the UK, and in the rest of the world[6]. The data are (largely) taken from published sources and are consistent with published metrics from the Office for National Statistics. Or greenhouse gas estimates arise from a more detailed breakdown of those published by the Welsh Government[7] and are thus Wales (but not Merthyr) bespoke.

We report organisational greenhouse gas emissions across *Scope 1* direct emissions (from fuel burn, gas leakage agricultural enteric[8] emissions etc.); *Scope 2* emissions from purchased grid electricity and mains gas; and *Scope 3* indirect emissions, which are those that arise, conceptually 'because' of the organisation but not *by* the organisation – the clearest example being GHGs arising along the length of the organisational supply chain.

In common with other service activities that that have relatively limited onsite/direct fuel burn, and modest electricity and heating requirements, indirect, 'Scope 3' emissions are likely to dominate the overall GHG footprint. There is however no clear guidance as to the boundaries of Scope 3 emissions, and individual organisations will make different choices in this regard.

[5] For a full discussion see Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: foundations and extensions*. Cambridge university press.
[6] The compilation approach for the IO Tables – together with detail on data sources, and limitations and caveats, and a summary IO Table, are detailed at https://orca.cardiff.ac.uk/id/eprint/151984/
[7] https://statswales.gov.wales/Catalogue/Environment-and-Countryside/Greenhouse-Gas/emissionsofgreenhousegases-by-year
[8] Cow burps; https://en.wikipedia.org/wiki/Enteric_fermentation

Our series of reports will take a holistic view – estimating not only the Scope 3 emissions in the MVH supply chain, but also emissions consequent on the fuels and electricity used in MVH-owned houses[9], and providing an estimate of GHGs associated with tenants/residents' consumption. The inclusion of these last estimates in these (later) reports does not imply MVH has direct responsibility for them (or is able to reduce them) but are provided to contextualise the scale of direct MVH emissions – and also as a reminder that often-low income MVH residents may poorly placed to respond to climate (and indeed energy) transitions.

It is important to note that IO is essentially an 'average' analysis. Thus, whilst the estimates of direct GHG emissions are based upon organisational-specific detail, the indirect (supply chain) effects assume MVH purchases follow Welsh-average organisational patterns for each of our 64 industrial sectors. Construction materials purchased for housing repair are somewhat of a special case which we discuss in Section 3.2.

We present our results in tonnes of 'CO2 equivalent' GHG emissions (CO2e). There is a 'basket' of gases that have climate implications, emitted in different proportions by different processes, including carbon dioxide (CO2), methane and nitrous oxide. They are often reported as a single term, weighted to reflect their global warming potential relative to CO2 – CO2 equivalent, or $CO2_e$[10].

Individual sub-sections also detail methodological approaches specific to that part of the GHG emissions.

2.2 Data

Our IO and carbon footprint analysis benefits from an extremely detailed breakdown of operational expenditure. Merthyr Valley Homes provided the research team with a detailed set of data covering its financial and operational activities including,

- An accounting of income by source
- Expenditure by detailed commodity and type of service, including sub-contract and recharges
- Geographic location of supply (where available; estimated by the research team where not)
- Estimates of employment, by full time, part time and temporary staff

[9] Indeed, these might properly be considered Scope1 & 2 as MVH own the asset, but due to the nature of our data sources, and to better inform organisational net-zero strategy we report them in a later document.
[10] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Kyoto_basket

- Wage spending, including NI and pensions.
- Direct electricity use within office buildings
- Direct mains gas use within office buildings
- Estimates of vehicle mileage.

These data on 'direct' activities inform our input to the environmentally extended IO modelling process. A number of steps are required before we can undertake this step;

- VAT is removed from the purchases (as this does not accrue to Wales, immediately at least)
- Purchases from outside the region are removed for each detailed commodity for separate analysis[11]
- Items reported as outgoings but which do not comprise an economic demand are removed – for example depreciation of assets, and various capitalisations.
- Pensions, NI and taxed are deducted from reported gross wage spend to as these do not represent disposable household income that has multiplier impacts.

GHG emissions consequent on fuel use onsite and in vehicles are estimated directly from fuel burn using BEIS conversion factors[12]. The complexities of estimating emission from grid electricity are discussed in Section 3.1 following.

[11] Direct imports and UK-sources services are estimated to create around 150 tonnes of $CO2_e$, reported as part of the supply chain in Section 3.2

[12] See https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

3 Results

3.1 Direct Fuel, Gas and Electricity Use (Scope 1 & 2)

MVH does not operate any fuel combustion activities at its office sites. It's 'Scope 1' greenhouse gas emissions thus relate to fuel for its fleet of directly owned vehicles – largely commercial vehicles used for housing maintenance. This fuel burn, just under 70,000 litres in 2021/2 gave rise to 169 tonnes of CO2 emissions (along with, of course a variety of emissions and particulates that negatively impact local air quality.

Continuing to focus on office sites, Scope 2 emissions – those from purchased gas and grid electricity are less significant. The three included office sites burned around 105,000 kWh of gas in the period, with some 19.5 tonnes of CO2e consequent.

Moving to electricity, use of UK Government GHG conversion factors suggests that the 17,000 kWh of electricity use in offices would equate to 36 tonnes of CO2e. However, the south Wales grid is more carbon intense than the UK average used in the BEIS conversion from delivered kWh to greenhouse gases. South Wales typically is not supplied by the (largely North Sea) offshore wind and nuclear power which lower UK grid carbon intensity, and the contribution of onshore wind and solar PV in the region is modest[13].

Analysis, albeit for 2019[14], suggests the south Wales grid was on average over the year some 60% more carbon intense (per kWh) than the UK average. This means that MVH CO2 from grid electricity may in reality total around 60 tonnes, increasing Scope 2 emissions from a 'BEIS compliant' estimate of 56 tonnes to 91 tonnes.

13 See https://www.carbonintensity.org.uk/

14 Unpublished but available from the author. Note, south Wales 2022 grid intensity unlikely to have reduced since with very modest renewables roll-out; see https://gov.wales/energy-generation-wales-2020 for example.

We present BEIS-compliant (lower) estimates in the figures following to enable comparison with Scope 2 emissions estimates that have been (or will be) presented by other organisations, but it is worth remembering 'nature does not care' how we derive our estimates – the actual MVH climate emissions will be those associated with a local energy mix that is typically over 90% gas-fired[15].

Summing these totals suggests that MVH total Scope 1 and 2 emissions for 2021-22 were around 225 tonnes of CO2-equivalent, with around three quarters arising from vehicle emissions.

Figure 1 Merthyr Valley Homes Scope 1 & 2 Greenhouse Gas Emissions (2021-22)

	Tonnes CO2e	**Percent**
Direct Fuel Burn (Vehicles) (Scope 1)	169	75.3%
Grid Electricity (Scope 2)	36	16.1%
Mains Gas (Scope 2)	20	8.7%
Total Scope 1 & 2	**225**	**100**

3.2 Greenhouse Gas in the Supply Chain (Scope 3)

In this section we estimate the GHGs that arise in the MVH supply chain – including as supplier companies themselves burn fuel, purchase electricity etc. A significant proportion of purchases – around £1m in 2021-22 – comprises materials for housing maintenance, ranging from finished metal products like nails and screws through to cements and plaster products, wood products etc. These products, typically, have significant emissions in their own production processes, and we treat them separately in the analysis.

As Figure 2 shows, supply chain GHGs are significant at 1,329 tonnes of $CO2_e$ – indeed, some five times higher than Scope 1 and 2 combined, even here discounting the purchase of repair materials (see Figure 3). Almost a third (404 tonnes) of these emissions were in manufacturing sectors, whilst 344 tonnes arose as companies supplying MVH (in Wales and beyond) used electricity and gas to create products and services then provided to MVH.

[15] Note that our Scope 3 emissions estimates in Sections 3.2 and 3.3 reflect the 'reality' of the south Wales grid, using higher estimates. This is because other organisations looking to present Wales-bespoke supply chain emissions can only, properly do so using the Wales-specific electricity mix, or the Input-Output tables themselves.

A further 16% of emissions were from sewerage and waste remediation services (including over £180,000 spend by MVH directly on skips and waste disposal).

Figure 2 - Greenhouse Gases in the Supply Chain

	Tonnes CO2e	Percent
Primary Industries	51	3.9%
Manufacturing	404	30.4%
Electricity, gas & water supply	344	25.9%
Sewerage & waste treatment	214	16.1%
Construction	169	12.7%
Services	147	11.0%
Total	1,329	100.0%

As noted earlier we treat materials for housing maintenance, over £1m of spend in 2021/22, separately from the above. There are very significant numbers of purchases made in this regard each year (well over 15,000) and covering a very wide range of materials.

Information on the procurement of maintenance materials is extensive, covering individual purchases, but Is not available by Industry of supply, thus not easily coded to our Input Output groups for analysis. We therefore take a one-week sample of purchases (from May 2021), examining the text description of the items (over 350 in that week) to allocate the relevant spending to their best-fit IO group. This estimate Is then grossed to represent all MVH materials spending for the financial year.

Undertaking this analysis suggests that the GHG emissions from repair and maintenance materials for MVH' 4,000 homes are significant. At over 1,100 tonnes of CO2e, these are similar in size all other Scope 3 procurement-related greenhouse gases combined, and thus also much larger than Scope 1 and 2 emissions. This is despite the fact that purchases for home repair and maintenance are some six times lower (in money terms) than the total purchases elsewhere in the non-wage supply chain. This indicates a very high level of carbon intensity in this area of the MVH supply chain, largely of primary and manufactured goods.

Digging a little deeper, around two thirds of these materials emissions, covering one third of materials spend, arise in the 'non-metallic minerals' sector, with this covering many plaster, stone, tile, and cement products - with significant supply chain demands then back to GHG-intense mining and quarrying. Direct purchase of unprocessed mined aggregates and other primary products comprise another 10% of emissions.

Other large contributors to GHG emissions from materials are metals and fabricated metal products, wood products, and chemical products (Figure 3). Note, as the Impact of emissions from utilities shows, these product-GHG estimates derive from the whole MVH supply chain, not just direct purchases.

Figure 3 - The GHG Impact of Repair & Maintenance Materials

Total Repair & Maintenance Materials	**1,134**	**100%**
Of which, selected key GHG emissions sectors:		
Non-metallic mineral products (including tiles, plasterboard etc)	*668*	*59%*
Mining & quarrying (inc aggregates, sand etc.)	*108*	*10%*
Metals & metal products	*94*	*8%*
Electricity, gas and water	*91*	*8%*
Wood products	*41*	*4%*
Chemicals (inc. sealants etc.)	*38*	*3%*

It should be noted that our estimates here of GHG emission are uncertain, based upon the sampling of a single week in a financial year, and subject to some uncertainly In the manual allocation of products to IO sectors[16]. However, it is clearly the case that maintaining MVH-owned homes currently comprises a significant carbon burden - and reducing that burden is unlikely to be straightforward[17].

3.3 The Impact of Wages (Scope 3)

The operational spending of MVH is split roughly in half between wages (including employers' pensions and NIC contributions), and the non-wage spending that leads to the GHG emissions covered in 3.1 and 3.2 above.

MVH wages also cause GHG emissions, as employees then support (some or all of) their household expenditure using their MVH earned income. These GHGs are, of course, primarily the responsibility of employees' households, not Merthyr Valleys Homes. Similarly, their reduction (to net-zero) is primarily a task for those households, for firms, and for government organisations that invest in supporting infrastructures.

[16] e.g. we cannot always be certain if a 'bracket' is plastic or metal.
[17] https://www.bbc.co.uk/sounds/play/m001brly#xtor

We nonetheless include an estimate of wage-related emissions for two reasons. Firstly, it is illustrative to reveal the relative 'weight' of individual consumption in comparison to organisational spending in GHG emissions, and secondly MVH is able to engage in consumption-related GHG emissions via engagement with staff on climate change, and in staff-related emissions reductions actions[18]. For example, companies have sought to reduce climate emissions from commuting via (nationally-sponsored) cycle-to-work schemes and smarter pricing and allocation of workplace parking[19].

Here then we estimate GHG from household consumption in the following way:

- Gross wages, with a total for the part that comprises employers' NIC and pension contributions for 2021/22 was obtained from MVH
- An estimate for deductions was made using Wales-average ratios for pensions, income tax and employees NICs relevant to a person on an 'MVH average' wage
- The net take-home pay, estimated at just over £5.8m, is entered as a 'shock' into the Input-Output Tables for Wales, which then provide an estimate of resultant GHGs embodied in consumption goods (including heating, electricity and transport), both in Wales and beyond.

There are some caveats and limitations to our analysis that should be remembered in the subsequent discussion, notably:

- Our analysis assumed all take-home pay is spent, and does not account for savings (or draw-down from savings) that may occur to defer consumption into a different year – and have GHG consequences elsewhere as they fund investment
- Similarly, employee (and employer) pension contributions are excluded from this analysis for methodological and data reasons, although these funds are extremely climate-relevant
- We estimate take-home pay based on the 'average' MVH employee wage, although a fuller internal analysis could estimate this for multiple pay bands
- Employee spending is modelled on a 'Wales average' household, with this estimated from Wales-regional results from UK household surveys. Moreover, these data are for 2019 so pandemic-related changes in consumption are not covered here
- Although we estimate GHGs from transport and heat/lighting here, these estimates, based on expenditure, are not as accurate as those based direct energy consumption (should they be available)

[18] For example the MVH headquarters has a car park EV charger.

[19] Note, however that for pandemic-related reasons, we have not directly estimated MVH employees' commuting emissions – these will be a part of the overall wage-emissions 'basket'.

- Our electricity estimates are reported to reflect the higher carbon-intensity south Wales grid (for electricity and within-Wales produced goods and services), rather than BEIS-compliant.

The above notwithstanding, the remainder of this section estimates the wage-related consumption GHGs of MVH employees' households at 1,157 tonnes of $CO2_e$. This is very similar in scale to the GHS arising from repair materials (1.134), and from the rest of the supply chain (1,172).

The above equates to around 5 tonnes of $CO2_e$ for each MVH full-time equivalent employee. This figure is somewhat lower than the per-person 'carbon footprint' numbers reported elsewhere[20]. This is likely firstly, because we are missing some elements of household consumption – for example those supported by non-wage income such as benefits and pensions – secondly, because our wage-driven approach is likely less accurate than approaches which focus on household expenditure more directly, and may include direct measures of fuel burn and travel distances etc., and thirdly because our methodology does not currently (easily) allow an estimate of the GHG footprint of goods that are purchased directly by households from outside Wales.

We would thus suggest that the totals presented in Figure 3 are considered a conservative and illustrative estimate of employee GHG emissions. We have further stretched the analysis to provide an illustrative estimate of the sorts of sectors where the model suggests these GHG emissions arise. Again, whilst household-based approaches would be more appropriate here, our analysis suggests that home heating and power will be a very important part of any decarbonisation drive.

This is especially so as, post-pandemic, the working from home phenomenon looks set to continue, at least in part. This means that an increased element of GHGs created 'in pursuit of work' will be at home, and thus invisible to employing organisations – but still needful of reduction and eventual elimination.

[20] For example, 8.0 tonnes in our study of Treherbert; see https://orca.cardiff.ac.uk/id/eprint/150091/

Figure 3 - The GHG impacts of MVH Wage Expenditure

	CO2e(t)	**%**
Utilities & waste	653	56.4%
Agriculture, Food & drink, Manufactures & their distribution	292	25.3%
Transport & fuels	170	14.7%
Other services	42	3.7%
Total	**1,157**	**100%**

4 Summary

4.1 Assessing the MVH Operational Carbon Footprint

Drawing together the results from across Section 3 reveals an operational carbon footprint – i.e. relating to the circa £21m expenditure in 2021/22 – of 3,845 tonnes. This, of course, excludes the GHGs emitted from MVH-owned housing stock for heating, lighting and power (which will be addressed in a future report due early 2023).

It is worth noting that over 90% of operational emissions are 'Scope 3' – so decarbonisation of *office* electricity, heat and vehicle fuel will have only a modest impact – although the decarbonisation of housing stock will of course be key. We have, of course, drawn Scope 3 widely here to include employee wage effects.

The supply chain for goods, services, subcontracting and repair/maintenance materials comprises almost two thirds of this footprint. Decarbonisation, therefore, must be a work of partnership.

Figure 4 - The Operational Carbon Footprint

	CO2e(t)	%
Fuel Burn, Electricity & Gas (Scope 1 & 2)	225	5.9%
Supply Chain	1,329	34.6%
Housing Repair & Maintenance	1,134	29.5%
Employee Wages	1,157	30.1%
Total	**3,845**	100.0%

It is not possible to say whether this footprint is 'good or bad' given the lack of comparator data available across the sector, either in Wales or elsewhere[21]. It is worth noting that it amounts to 17 tonnes per FTE employee – or around one tonne of $CO2_e$ for every home under management. Irrespective, it is likely to be challenging to address.

[21] Some intelligence is available, for example see Orbit who estimate their operational footprint at (it seems) 6,215 tonnes, albeit in a rather confusing report. https://www.orbitgroup.org.uk/media/2650/net-zero-carbon-roadmap.pdf

4.2 Carbon Reduction: An Initial Assessment of Opportunities

Following this first report there are some emerging themes and issues which could be considered in MVH carbon reduction strategy. The organisation might consider:

a. Appropriate and Reasonable Reduction of Scope 1 and 2 Emissions

We noted that Scopes 1 and 2 are minor elements of aggregate GHG emissions but they are important for other reasons. Critically, appropriate control and reduction of an organisation's 'closest' emissions will be required to build trust and respect with tenants, and with other stakeholders in wider carbon reduction networks. We would suggest;

- If not already underway, an explicit strategy and costing for reducing Scope 1 emissions to zero, which is likely to mean the electrification of the fleet[22]. This is most likely appropriate at the end-of-lease or end-of-life for individual vehicles, as the carbon payback times for vehicle battery manufacturing are substantial, especially in south Wales' high-carbon grid[23]. This strategy should be clearly communicated in any MVH climate communications.
- Similarly, an assessment of the potential for reducing GHG from grid electricity. Whilst businesses have the option of 'green' tariffs from large suppliers, these often lever well-established – i.e. old – renewables (such as Scotland-based hydro) for zero carbon supply, and do little to incentivise new green generation. An assessment of supplier opportunities where bills fund new generation capacity would be worthwhile.
- The potential for off-grid/private wire or self-generation is unclear – either to serve office locations or homes. There are examples of such zero-carbon generation emerging across Wales, notably Morrison Hospital which has so far saved circa £1m on bills via ownership of its own solar farm some 3km distant[24]. Whilst this scale of opportunity might be unavailable to MVH, an assessment of the generation potential on its existing land, and built estate would be informative. A formal assessment of the potential for rooftop PV on homes could be undertaken at the same time, with a proper consideration of how any consequent costs and benefits could be shared between MVH and tenants.

[22] Given currently available technology

[23] The author's own estimates suggest around 30,000 miles of grid-powered travel before a 50kWh battery becomes 'carbon positive'.

[24] https://www.bbc.co.uk/news/uk-wales-63664878.amp

b. Toward Net-Zero Maintenance of Homes

A significant proportion of MVH Scope 3 supply chain emissions relate to the day-to-day repair and upgrade of tenants' homes[25] - over 300kg per home. Given the majority of MVH homes will, in 2050, be those of today, this is a significant issue. Whilst there has been extensive discussion of how to reduce householders' energy consumption in old and poor housing, for example through whole-house retrofit, less has been written about how ongoing maintenance in such properties creates a carbon burden. Much of this GHG footprint is, given current levels of technology, outside the ability of MVH to address[26]. There are, however, a number of useful questions MVH could address.

- Firstly, whether existing procurement approaches for materials is fit for purpose in terms of ensuring waste is minimised, following the "reduce *[only purchase what is really needed]*, reuse *[ensure materials can be stored and reallocated between jobs/homes, and maintenance staff are aware of this need]* and recycle" hierarchy.
- Secondly, whether the procurement of maintenance materials – notably fixings in plastic and steel, plaster- and other boarding, cements etc. currently considers whole-life GHG emissions – i.e. in manufacture, installation, use and disposal[27]. 'Carbon blind' procurement is likely to be non-resilient procurement, tying in the organisation to fabrics and services which are high cost – both carbon and financial – in the medium term. Meanwhile, incorporating carbon awareness into procurement (perhaps gradually) will help alert MVH to new opportunities as they develop, including, for example, bioplastics and alternative cements[28].
- Thirdly, whether there is an opportunity to create a 'pilot zero-carbon home(s)' to act as a test-bed for innovative and low carbon maintenance approaches at low cost (perhaps in conjunction with 'low carbon day-to-day living'). Whilst this would be a useful complement to MVH's PassivHaus investments, it is likely to be complex to develop, and advice might be sought from third party experts in terms of scope and approach.

25 Although we accept we have only sampled a small part of annual spend.
26 See https://www.nature.com/articles/d41586-022-00758-4 for prospects.
27 This is, of course a question to be asked more generally in procurement.
28 See https://www.mdpi.com/1747688; https://www.sciencedirect.com/science/article/abs/pii/S0959652617303876

c. *Informed Colleagues*

Merthyr Valley Homes already recognises the value of carbon literacy amongst its staff. Such literacy has proved useful – and arguably transformative – across industries and workplaces. However, MVH staff cross a number of industries and occupations and 'generic' literacy training may not be adequate to ensure, for example, homes and places staff can make the correct technical choices in their daily activities. The critical need for knowledge development and exchange in zero-carbon construction has been noted, along with significant current deficiencies[29]. Carbon literacy for technical staff may be available and worthwhile to embed.

4.3 Next Steps

This report has detailed the organisational GHG impact of MVH, consequent on £21m of operational spending. There are, however, likely-significant MVH-related climate impact not captured by this analysis – not least arising from the some-4,000 homes that MVH owns and manages in and around the town of Merthyr.

These GHG emissions will arise from heating, lighting and power. They will be emitted in MVH-owned homes, from gas boilers owned by MVH, but using gas purchased by tenants, and in electricity power stations following purchases of power by those same tenants. The level of these emissions – conceptually crossing *all* Scopes – will depend upon both the fabric and nature of the buildings, and on the behaviour and knowledge of tenants.

Our next report will estimate the level of greenhouse gas emissions consequent on fossil fuel use in and for MVH homes.

[29] https://www.tandfonline.com/doi/full/10.1080/09613218.2016.1086872; https://kclpure.kcl.ac.uk/portal/en/publications/transforming-vocational-education-and-training-for-nearly-zeroenergy-building(e240180a-95a9-49ba-b8fe-9bfda6664c58).html; https://www.tandfonline.com/doi/abs/10.1080/15623599.2022.2110642.